Naval Fuels & Lubricants
Cross Functional Team
Research Report

Navy Coalescence Test on Camelina HRJ5 Fuel

NF&LCFT REPORT 441/12-012

20 June 2012

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MEARNS.DOUGLAS.F.1229733199	Digitally signed by MEARNS.DOUGLAS.F.1229733199 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USN, cn=MEARNS.DOUGLAS.F.1229733199 Date: 2013.04.12 07:55:51 -04'00'

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EXECUTIVE SUMMARY

The Navy Coalescence Test (NCT) is a fit-for-purpose test which uses a specially manufactured small filter/coalescer cell to simulate the performance of a full scale filter/coalesce system while utilizing a small volume of fuel. This testing is designed to predict the performance of the filter/coalescer systems currently in use in the fleet.

Recently the US Navy has embarked on a program to reduce dependence on foreign oil and utilize fuel from sources which are renewable within the United States. The fuel used in this test is made using camelina seed as the feed stock. The camelina feed stock fuel performed as well or better than petroleum based JP-5 in the NCT. Therefore it is recommended to continue with additional fit-for- purpose testing.

LIST OF FIGURES

LIST OF ACRONYMS/ABBREVIATIONS

NCT... Navy Coalescence Test

PPM. ……………………………………………………………………...parts per million

HRJ .... ……………………………………..…. Hydroprocessed Renewable Jet fuel

DEFINITIONS

Turnover..................amount of time it takes to flow the entire volume of fluid in a container, also known as resonance time

Dissolved Water......water that is in solution with the fuel i.e. at or below the saturation point

Free Water ....water in a multi-fluid stream which is above the fluids saturation point

Element ....a separation device which acts upon a fluid stream, these may include filters, coalescers or separators

Coalescence............. the ability to shed water from fuel

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Navy Coalescence Test on Camelina HRJ5 Fuel

1.0 BACKGROUND

The Navy Coalescence Test (NCT) is a screening tool to determine the impact of fuel chemistry, fuel, and/or additives on filter-separator performance. The NCT is a scaled down version of a full-scale filter coalescer. The NCT utilizes a miniature version of a full size coalescer and separator assembled in a capsule. The capsule is engineered to have the same flow per unit area as a full size coalescer. The single pass flow rate is 100 mls/min. The test is comprised of flowing fuel, injecting a known amount of water upstream of the coalescer, and measuring the water concentration in the fuel downstream of the test capsule. The total water content in the fuel is measured at the 1) outlet of the tank (prior to water injection), 2) coalescer inlet (after water injection), and 3) coalescer outlet. By measuring and graphing the results of the water levels at those three points, the effects on coalescence can be determined. When coalescence is not affected, the tank and outlet water levels are close in value and give consistent results. When coalescence is compromised, the inlet and outlet levels of the coalescer are closer and give erratic results. The standard test duration is 80 hours. A flow schematic for the NCT is shown in Figure 1.

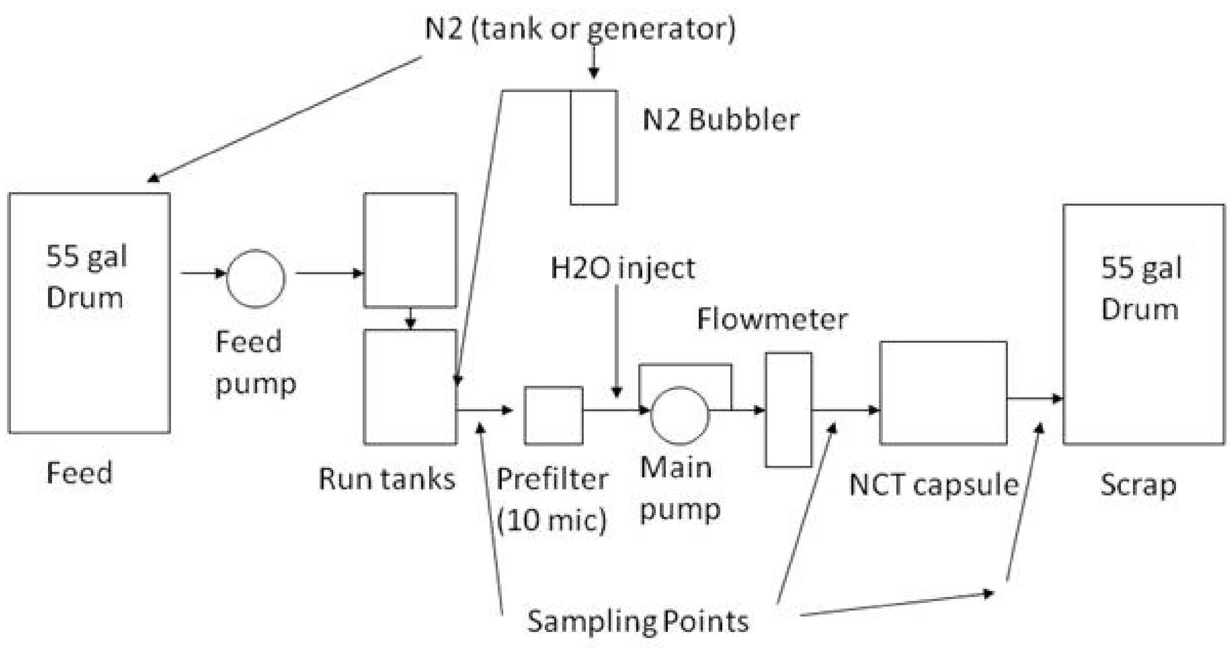

Figure 1: NCT Flow Schematic

The US Navy (USN) uses JP-5 aviation fuel for shipboard operations which has traditionally been derived from petroleum sources. Recently the USN has embarked on a program to reduce dependence on foreign oil and utilize fuel from sources which are renewable within the United

States. This report covers the NCT testing of JP-5 composed of approximately 50% fuel synthesized from camelina seed.

2.0 OBJECTIVE

The objective of this test is to determine the water shedding or coalescence properties of the test fuel. Free water levels upstream and downstream of the filter/coalesce test cell will be compared to a saturated level of water in the same fuel. Water is injected upstream of the filter/coalescer. A passing fuel will have downstream measurements which track with the saturated levels instead of the upstream levels. This will indicate satisfactory water separation properties of the test fuel.

3.0 APPROACH

Testing was conducted in accordance with the NCT Standard Work Package (SWP44FL-003). The base fuel was stored in epoxy lined drums, and put through a recirculating filtration stand before it entered the test rig. This is designed to remove any contaminants and establish a contaminant free baseline for the fuel. Each drum was recirculated with a drum pump for 22 turnovers to solubalize any large contaminants in the fuel stream and then recirculated for 122 turnovers through a series of filter/coalescers to remove any contaminants.

Once the fuel was contaminant free, it was placed in the test rig. Fuel drums were pressurized with nitrogen to both offset the vacuum produced by the feed pump and inert the system. The rig's feed pump pumps the fuel into a feed tank where it is injected with a feed of nitrogen and de-ionized water. This enabled the fuel to stabilize at a level where it is saturated with dissolved water. A sample of the fuel at this stage is tested using a Karl Fischer coulometric titrator, which reads the total parts per million (ppm) of water in the fuel. This reading is known as the saturated tank level.

The next step injects a constant amount of free water into the fuel stream. This injection rate was set using an explosion-proof electric needle injection pump and a syringe of de-ionized water. The target level of free water injection is 200-300 ppm. This condition was chosen because it represents a significant increase which could be seen in real field conditions. The saturated fuel stream is pumped through the rig using the test pump. This action atomizes the injected water stream with the water saturated fuel stream through the use of recirculation valves. Three samples of this fuel are tested in the Karl Fischer to give an average reading of the total water upstream of the test element housing. These samples are noted as the upstream readings.

The last step is to flow the water and fuel through the filter/coalescer cell test housing. The filter/coalescer and test separator will act on the fuel to separate the water from the fuel using both size occlusion and polarity of materials. Once the fuel has passed through the housing, three samples are tested in the Karl Fischer to give an average reading of the total water at this point in the test rig. These samples are known as the downstream samples.

The test was run for 80 hours of fuel flow through the test element housing at a rate of 100 milliliters per minute. During this time the 7 Karl Fischer measurements above were measured once an hour. In addition, the total and differential pressures across the test element were measured. If the differential pressure is greater than 15 psi, the filter has been compromised and the test will be reported as a failure.

In order to pass the test, the difference in water levels between the saturated tank and the downstream readings must be within 100 ppm of each other. If for four or more hours the difference in average readings is greater than 100 ppm, the test will be reported as a failure. The 100 ppm condition has been chosen because it allows for variations in the fuel sample, as well as random events such as excess water concentration upstream or incomplete saturation due to variations in nitrogen pressure and flow.

4.0 DISCUSSION

The HRJ5 fuel was tested to determine its viability as a drop in replacement for petroleum JP-5. No additives were present in the fuel. The saturated, upstream and downstream total water concentrations in the fuel stream are graphically represented below in Figure 2. These are graphed by test hour to show the trends in the water levels over the test duration.

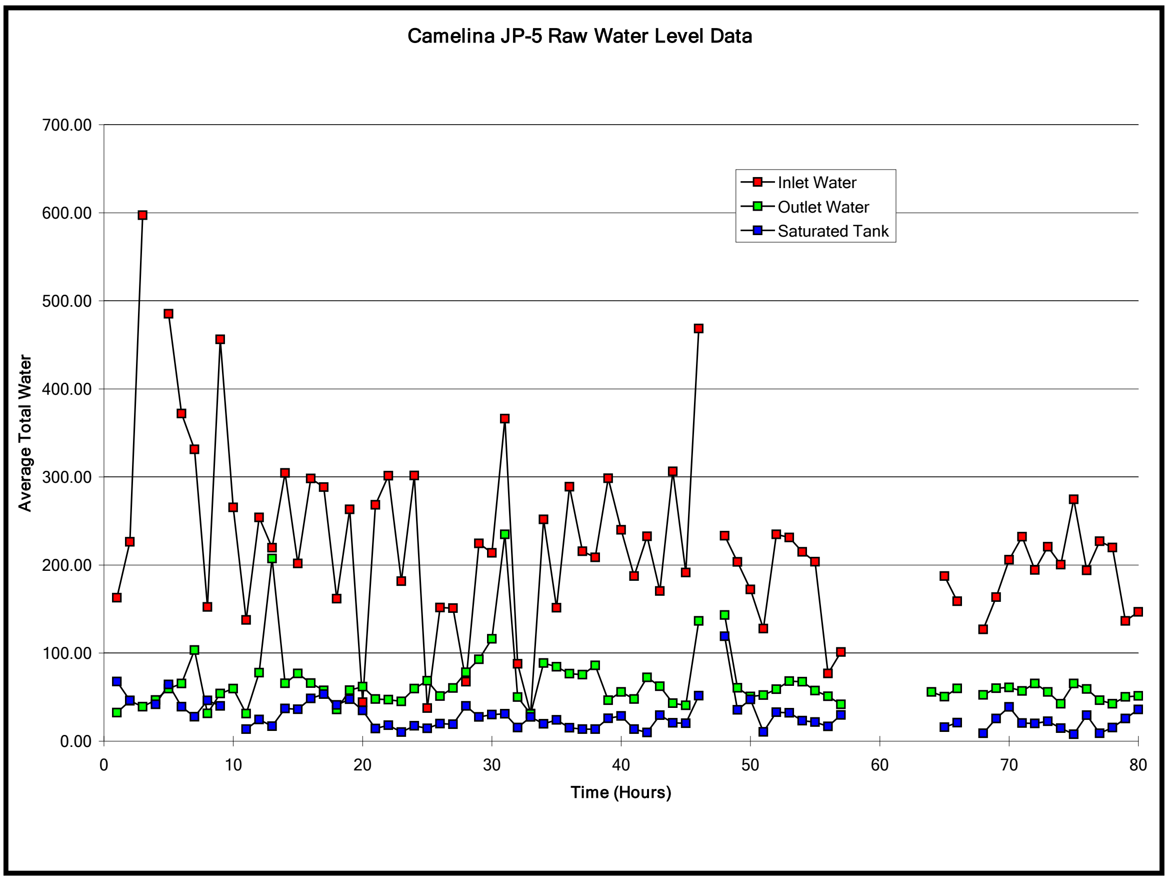

Figure 2: Raw water level data by test hour

As shown in the graph, the injected water level varied in concentration, but remained well in excess of the saturated level. Due to equipment issues with the Karl Fischer titrators, there were a few data points around the 60 hour mark that are not reported; however since the trends before and after these times are fairly linear, the test is considered valid. The average injected water concentration is 187 ppm.

The greatest water separation is seen when comparing the downstream fuel with the saturated fuel in order to see how well the test element removes the injected free water. The difference between the saturated fuel and the downstream fuel is seen in Figure 3 below.

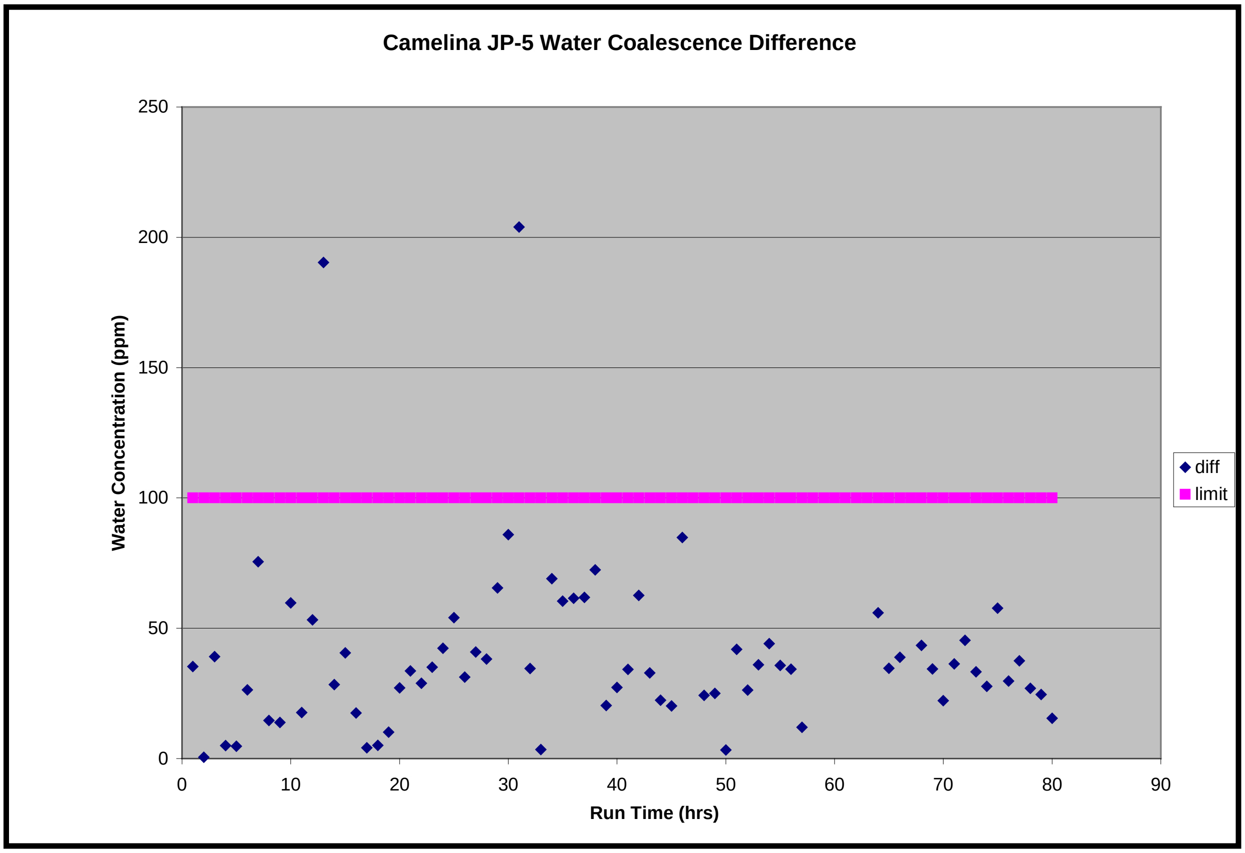

Figure 3. Calculated Water Coalescence Data

Figure 3 shows that all but two points were well under the 100 ppm limit. The average difference between the saturated and downstream water levels was 39 ppm indicating satisfactory coalescence. The differential pressure was between 4-6 psi throughout the test, indicating that this fuel did not have an adverse affect on system pressure.

5.0 CONCLUSIONS

HRJ5 produced from camelina based feed stock passes all the NCT requirements satisfactorily.

6.0 RECOMMENDATIONS

HRJ5 produced from camelina based feed stock is recommended for further testing.

7.0 REFERENCES

SWP44FL-003 Navy Fuels and Lubricants CFT Navy Coalescence Tester (NCT)

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APPENDIX A
Table A-1 Test Data

Run Time (test hour)	avg. inlet (ppm)	avg. outlet (ppm)	avg. tank (ppm)	dP (psi)
1	162.95	32.47	67.80	6
2	226.35	45.77	46.30	6
3	597.30	39.10	[redacted]	6
4	[redacted]	46.65	41.70	6
5	485.20	59.70	64.40	6
6	372.10	65.47	39.10	6
7	331.23	103.37	27.80	6
8	152.33	31.60	46.20	3
9	456.20	53.97	40.10	3
10	265.35	59.70	[redacted]	4
11	137.57	31.23	13.60	3
12	253.93	77.80	24.60	3
13	219.55	207.27	16.90	3
14	304.55	65.60	37.20	3
15	201.70	76.85	36.30	5
16	298.35	65.90	48.40	6
17	288.45	57.60	53.50	6
18	161.70	35.97	41.00	6
19	263.13	57.85	47.70	6
20	44.25	61.93	34.80	4
21	268.30	47.90	14.30	4
22	301.43	47.03	18.10	4
23	181.75	45.23	10.20	3
24	301.57	59.73	17.40	4
25	37.60	68.63	14.60	4
26	151.70	51.20	19.90	3
27	151.10	60.23	19.30	3
28	67.37	78.17	40.00	3
29	224.47	92.87	27.40	4
30	213.87	116.13	30.20	4
31	366.10	234.93	31.00	10
32	87.90	49.97	15.40	4
33	31.20	30.83	27.40	4
34	251.90	88.67	19.60	3
35	151.40	84.50	24.10	4
36	288.93	76.57	15.10	4
37	215.70	75.53	13.70	4
38	208.75	86.00	13.60	5
39	298.57	46.40	26.00	4
40	240.03	55.77	28.50	4
41	187.37	47.90	13.70	4
42	232.53	72.37	9.80	4

Table A-1 Test Data (Continued)

Run Time (test hour)	avg. inlet (ppm)	avg. outlet (ppm)	avg. tank (ppm)	dP (psi)
43	170.40	62.40	29.50	4
44	306.27	43.10	20.70	3
45	191.37	40.60	20.40	3
46	468.60	136.50	51.70	3
47				0
48	233.25	143.27	119.00	4
49	203.63	60.63	35.60	4
50	172.17	50.67	47.40	4
51	127.70	52.30	10.40	4
52	234.80	59.07	32.80	4
53	231.23	68.13	32.10	4
54	214.93	67.40	23.30	4
55	203.77	57.33	21.60	4
56	76.90	50.97	16.70	4
57	101.23	41.83	29.80	4
58				4
59				4
60				4
61				4
62				4
63				4
64		55.93		4
65	187.40	50.53	15.90	4
66	158.93	59.93	21.10	4
67				4
68	126.97	52.43	9.00	4
69	163.60	60.10	25.70	4
70	206.00	61.03	38.80	4
71	232.03	56.87	20.50	4
72	194.37	65.47	20.10	4
73	220.73	55.90	22.60	4
74	200.33	42.53	14.80	4
75	274.67	65.47	7.80	4
76	194.00	59.23	29.50	4
77	227.00	46.40	8.90	4
78	219.93	42.37	15.40	4
79	136.47	50.30	25.70	4
80	146.70	51.37	35.90	4

Note: Issues with the Karl Fischer titrators precluded the capture of data at test hours 47, 58 though 64, and 67.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
06-20-2012

2. REPORT TYPE
Technical

3. DATES COVERED *(From - To)*
06-30-2010 to 07-21-2010

4. TITLE AND SUBTITLE
Navy Coalescence Test on Camelina HRJ5 Fuel

5a. CONTRACT NUMBER
N/A

5b. GRANT NUMBER
N/A

5c. PROGRAM ELEMENT NUMBER
N/A

6. AUTHOR(S)
Laing, Christopher; Author
Buffin, Jack; Editor
Kamin, Richard ; Editor
Mearns, Douglas ; Editor

5d. PROJECT NUMBER
N/A

5e. TASK NUMBER
N/A

5f. WORK UNIT NUMBER
N/A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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Patuxent River, MD 20670

8. PERFORMING ORGANIZATION REPORT NUMBER
NF&LCFT Report 441/12-012

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Chief of Naval Operations N42
2511 Jefferson Davis Highway
Arlington VA 22202

10. SPONSOR/MONITOR'S ACRONYM(S)
N/A

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
N/A

12. DISTRIBUTION / AVAILABILITY STATEMENT
A Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES
N/A

14. ABSTRACT
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15. SUBJECT TERMS
Navy Coalescence Test, NCT, BioFuel, HRJ5

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Douglas F. Mearns
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	Unclassified Unlimited	15	**19b. TELEPHONE NUMBER** *(include area code)* 301-757-3421